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Contribution from the Bureau of Entomology, L. O. Howard, Chief

October 2, 1913.

## THE POTATO-TUBER MOTH

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## INTRODUCTORY.

For many years the potato-tuber moth, known scientifically as *Phthorimæa operculella* Zell., has been the worst potato pest in California. It has now reached the State of Washington and southern Texas and menaces adjacent States. This insect feeds also upon tomato, eggplant, and tobacco, which do not, however, as a rule, suffer much injury. When it occurs on tobacco it is known as the splitworm.

The mature moth of this species, which is quite small and grayish in color, is shown in figure 1, *a*; the larva is shown in *b* and *c*; and the pupa in *d*. Sizes are indicated by the size lines in the figure.

The eggs may be laid upon the leaves or on other parts of the plants, and the minute caterpillars or worms quickly bore between the surfaces of the leaves or into the potato skin, which they mine in every direction, finally devouring the exterior. It is believed that there are two or more generations in the course of a summer, and certainly another one can be produced in store. It thus happens that this insect belongs to both truck-crop and stored-product insect pests.

An example of injury by this species to potatoes is shown in figure 2. At *a* is a section showing the eggs; at the left is a section of a badly infested potato containing two pits, *d* and *f*, in which the larva has been at work, while at *b* and *c* is shown the egg, highly magnified. Figure 3 gives an exterior view of a potato which has been destroyed by the tuber moth.

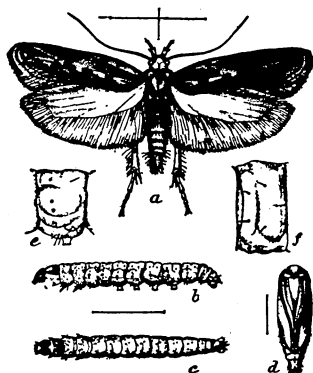


FIG. 1.—The potato-tuber moth (*Phthorimæa operculella*): *a*, Moth; *b*, larva, lateral view; *c*, larva, dorsal view; *d*, pupa; *e*, *f*, segments of larva, enlarged. (Redrawn from Riley and Howard.)

<sup>1</sup> The account here given is issued with the purpose of warning potato growers and giving general information in regard to remedies. Work was begun on this species in 1912 and will continue. This is a revised and amplified account, first published as Circular 162 of the Bureau of Entomology.

## DISTRIBUTION.

This species is widespread in its distribution, but in this country, until the year 1912, we did not know of its rapid dissemination. Abroad it is well known in Hawaii, all portions of Australia, New Zealand, Algeria, the West Indies, Peru, and many other countries, including southern Europe. As an enemy to tobacco it has been known for several years in Florida, and in North Carolina, South Carolina, and Virginia.

The species occurs in southern California practically wherever potatoes are grown commercially, extending its range northward to the Sacramento Valley.

As an enemy to eggplant and ground cherry it has been observed as far north as the District of Columbia.

The directions for applying remedies which follow are for the benefit of persons inquiring in regard to means of control. Which of these should be used can be best determined by trial in the different localities under the different conditions in which the insect exists. This applies especially to the question as to the best material for fumigation.

## EVIDENCE OF IMPORTANCE.

As evidence of the importance of the pest Mr. J. E. Graf, working under the direction of the writer, wrote:

In September, 1912, an unusual outbreak of this pest occurred at El Monte, Cal., due entirely to a combination of circumstances. Thousands of acres of potatoes were planted in southern California—many more than the market would stand. This meant that the market was continually clogged and the prices were poor, so that the crop was worked off very slowly. The tuber moth (*Phthorimæa operculella*) is always

found here, but the crop is generally handled so quickly and carefully that small loss results. This year, however, careless work and the leaving of potatoes in the ground too long have given the insect a tremendous start, and now its ravages are greater than ever before. A combination of the moth and low prices has so discouraged many of the growers that they are leaving their potatoes to rot, and as these are becoming infested there will be a great number of moths waiting for the fall potatoes. \* \* \*

Later, September 17, 1912, Mr. Graf wrote in regard to injury by this species that two growers near El Monte, Cal., lost \$90,000 and \$70,000, respectively, on potatoes that year. Items of this kind show the necessity of investigating the problem.

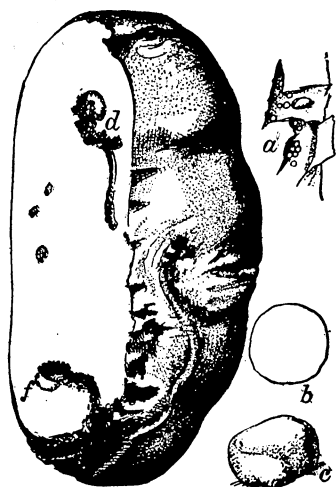


FIG. 2.—Work of the potato-tuber moth: *a*, Section of tuber, showing eye and eggs deposited about it; *b*, egg in outline; *c*, egg, lateral view; *d, f*, mines of larva in potato. *a*, Natural size; *b, c*, greatly enlarged; *d*, somewhat reduced. (Redrawn from Riley and Howard.)

Aside from numerous similar complaints, including the usual number from California for the past two years, this species has been received from Eagle Lake and Hallettsville, Tex.; San Jose, Costa Rica; Seattle, Auburn, and Yakima, Wash.; New York City, where it has not become acclimatized so far as known; Fort Collins, Colo.; and Larimore, N. Dak. These records include only occurrences on potato.

In the case of the last report the tuber moth was stated to have been imported into southern California in potatoes from China. It is doubtful if the species has been established in North Dakota, but inquiries have been made in regard to the danger of its being introduced there as well as into Minnesota and many other States.

### REMEDIES.

The potato-tuber moth is a difficult insect to control by any single method. It is not possible to reach the tuber worms in their mines in the potatoes or in the stalks or tubers while growing in the field, which makes it necessary to proceed against the pest by other methods. Of these, several must be employed to insure success.

#### CLEAN METHODS OF CULTIVATION.

The first measure consists in the maintenance of clean methods of cultivation. This implies that all infested potato plants and solanaceous weeds, such as ground cherry, bull nettles, horse nettles, and volunteer potato plants, growing in the same vicinity as the potatoes, must be destroyed. This can be done by prompt burning as soon as insect infestation is manifest. The burning of these weeds will eliminate places for the breeding of the insect or for its successful hibernation. Domestic animals, such as sheep and hogs, are valuable for the destruction of remnants and may be utilized by merely turning them into the field.

#### CROP ROTATION.

As in most other cases of insect injury, crop rotation is desirable where possible, and the cooperation of all potato growers of the neighborhood is practically a necessity. In certain cases, as, for ex-



FIG. 3.—Work of the potato-tuber moth. Exterior view of potato. (Original.)

ample, in a county where many potatoes are grown, it might be possible by legislation to enforce the discontinuance of potato planting for a year, requiring at the same time the destruction of the weeds which serve as food plants. There are several alternate food crops which do not suffer materially from this insect. About the best of these are leguminous crops, like beans, peas, cowpeas, alfalfa, and clover. These possess a dual value, as they all act as soil restorers. Sugar beets, celery, and crucifers are also good as alternate food crops. Grains may serve in the same way, as they are not attacked by the tuber moth.

Care in digging is advisable in order not to cut into the tuber or leave the dug potatoes in the field over night where reinfestation could occur.

#### FUMIGATION.

While all of these remedies are of value, the best remedy is the fumigation of infested tubers with bisulphid of carbon or hydrocyanic-acid gas. If bisulphid of carbon is used, it should be at the rate of 3 pounds to 1,000 cubic feet of air space, including the potatoes; 1 ounce to a barrel of 96 pounds' capacity would not be excessive. With an exposure of not more than 24 hours no harm should be done to the potatoes for planting. The bisulphid should be evaporated in tins, like pie plates or pie pans, and a cover should be placed on the top of the fumigating barrel or box so as to make it as nearly air-tight as possible. At the end of 24 hours the potatoes should be removed, placed in a fresh barrel, and closed up.

Where it can be conveniently done, hydrocyanic-acid gas should be used in a specially constructed fumigator (see fig. 4), also gas-tight. *In the case of bisulphid of carbon there is great danger in bringing the chemical into proximity to fire, such as a lighted lantern or cigar, for the gas is highly inflammable and even explosive.* Then, too, the bisulphid-of-carbon method costs slightly more than the hydrocyanic-acid-gas method.

Fumigation with hydrocyanic-acid gas, properly performed, is not dangerous, but if improperly performed it is decidedly dangerous to human and other animal life, as the fumes are very poisonous and are *deadly* when inhaled in any amount. This gas is more penetrating than bisulphid of carbon and can be used by an intelligent person without trouble, if he first familiarizes himself thoroughly with the procedure by carefully studying the printed directions or assisting some one who has had experience in this work. The cubic contents of the receptacle to be fumigated, on which is based the amount of chemicals to be used, can be readily computed.

The fumigating box shown in the illustration, which will presently be described, may merely be taken as an example of what can

be easily constructed to meet the purpose. In the case of this box the potatoes are best fumigated in bags, which can be piled one on top of another. If bins or other fumigators are used, the proportions will vary. They can be constructed longer or shorter and lower, according to the individual needs and desires of the potato grower.

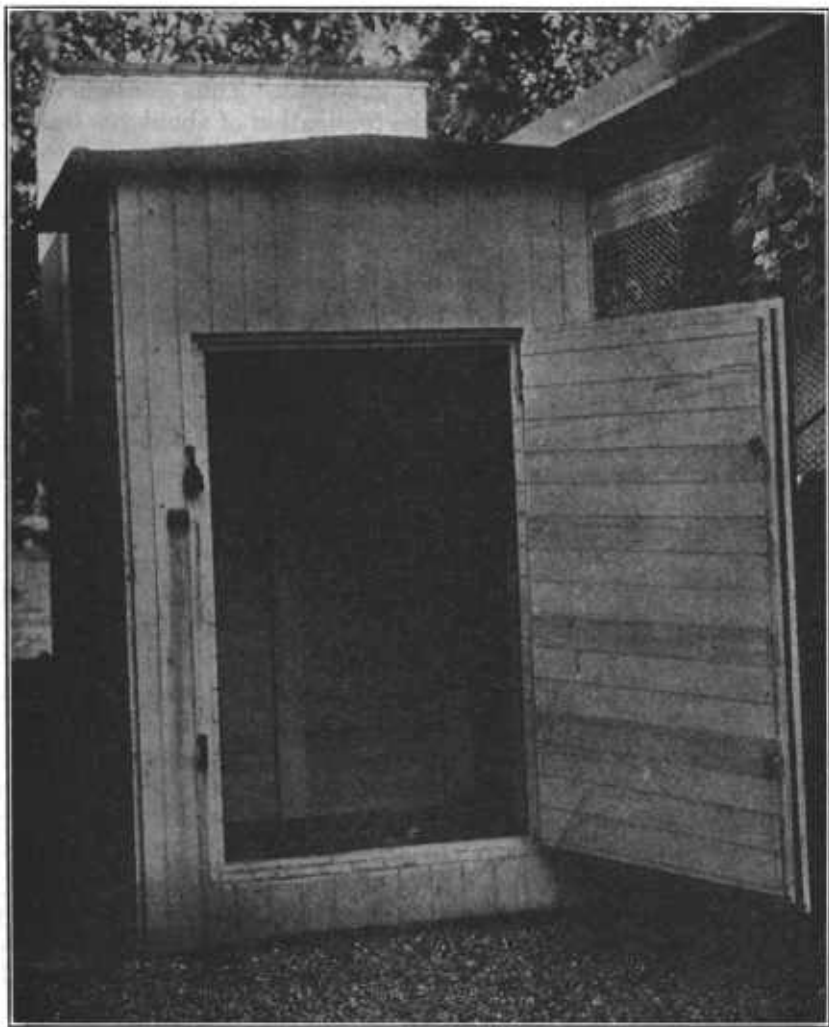


FIG. 4.—Fumigator used for stored products infested by insects. (Author's illustration.)

#### THE CONSTRUCTION OF A FUMIGATOR.

A building, box, or room (see fig. 4) of about 100 to 200 bushels capacity suitable for the fumigation of a quantity of potatoes would contain about 500 cubic feet. A fumigator of this cubic capacity might be built 8 feet square by 8 feet in height. A good, and perhaps

the best, means of preventing the escape of the gas is to line the fumigator with sheet tin, with soldered joints, and over sheathing. Another method is to sheath the room inside, cover the walls, ceiling, and floor with tarred or heavy building paper, with joints well lapped, and cover the inside with matched ceiling boards. The fumigator should always be equipped with a tight door in which the joints have been broken, similar to the door of a refrigerator or safe, and should close with two refrigerator catches against a thick felt weather strip, which should render it practically gas-tight. Thus constructed it would furnish sufficient space for the fumigation of about 200 bushels of material. There would also be sufficient space for the application and diffusion of the carbon bisulphid, hydrocyanic-acid gas, or other fumigant from the top with a charge more than necessary for the quantity of potatoes treated.

It sometimes happens that the price of potatoes is so low that the small grower can not well afford to expend the amount of money which would be necessary for the construction of a special fumigator. In such a case it would be advisable to use a barrel, preferably a large oil barrel, with a tight-fitting cover for fumigating. It is possible also to fumigate, but not thoroughly, piles of tubers by covering them as tightly as possible with canvas, such as 10-ounce duck or tarpaulin.

#### PROTECTION OF THE FALL CROP AND SEED POTATOES.

A special letter of warning against the ravages of the potato-tuber moth in the shape of a press notice has been sent broadcast to newspapers, as well as to others, throughout the country. The main facts in the case were founded on the experience of Mr. Graf in his investigations and in his dealings with the potato growers of southern California. Concisely stated, the warning is to enable potato growers to undertake special work with seed potatoes and with the fall crop.

For the protection of potatoes in fall against this pest it is urged that potato growers sort the potatoes for seed two weeks after digging and again two weeks later. The uninfested tubers should then be placed in a moth-proof bin. The infested tubers may be readily picked out because of the excrement of the larvæ which adheres by webbing to the outer skin of the potatoes. The tubers in the moth-proof bin, after final sorting, should be fumigated with carbon bisulphid (bisulphid of carbon) to destroy any moths which might have bred out or have obtained entrance through other means. Growers should now keep a careful lookout both in the field and among the fumigated tubers. At first those which have been fumigated should be inspected daily. Afterwards observations may be made every other day until finally once a week will suffice. If there should be any indication that the tuber moth is propagating, a second fumigation is in order.

This method of saving seed potatoes appears so simple, although effective, that it is feared that many growers may disregard it.

To grow all potatoes successfully the farmer should work overtime on a cleaning-up campaign which should begin at once on receipt of this bulletin. Small or useless tubers and tops should be promptly cleaned up and burned, and the land should be harrowed to break up clods and leave as few hiding places as possible for the moths. All weeds and other plants of the potato kind should be destroyed over large areas surrounding the potato fields.

It is particularly urged that potato growers cooperate in this work, which will lessen very materially the numbers of moths and hence reduce the chances for propagation. Could general cooperation be secured by legislation or otherwise it would be possible to restrict the distribution of this species to the area which it now occupies or to stamp it out where now established. Slipshod methods of raising potatoes at such a time as midsummer or early autumn are particularly dangerous, and in infested districts it is advisable in many cases to raise some crop other than potatoes, because unless protective and defensive measures are adopted at once there will be a serious reduction of the potato crop and similar trouble will be experienced during seasons to come.

